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Ocean Wind Speed Characteristic Over Malaysian Seas From Multi-Mission Satellite Altimeter During Monsoon Periods

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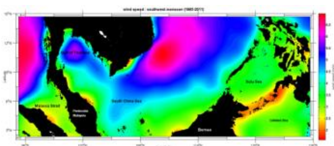
Graphical abstract



Abstract

The need for precise measurement of wind speed and growth of interest in offshore wind power has led to development of many measurements technique. This paper presents a study of wind speed characteristics during monsoon periods (north-east monsoon and south-west monsoon) over Malaysian seas using multi-mission satellite altimetry data from year 1993 to 2011. The study area covers in this study are Malacca Straits, South China Sea, Sulu Sea and Celebes Sea. From the result, the strongest winds are between Novembers to February, but on average, December is the strongest recorded wind speed at most locations. The South China Sea is the roughest region throughout the year compare to the other sea. It was concluded that using altimetry data, we can solve the disadvantage of conventional measurement in terms of spatial data distributions.

Keywords: Ocean Wind Speed; Satellite Altimeter; Monsoon Periods

Abstrak

Keperluan untuk ukuran tepat kelajuan angin dan pertumbuhan minat dalam tenaga angin luar pesisir telah membawa kepada pembangunan teknik banyak ukuran. Kertas kerja ini membentangkan kajian ciri-ciri kelajuan angin pada musim tengkujuh (utara-timur dan monsun barat daya monsoon) atas lautan Malaysia menggunakan data satelit altimetri pelbagai misi dari tahun 1993 hingga 2011. Kajian meliputi kawasan dalam penelitian ini adalah Selat Melaka, Laut China Selatan, Laut Sulu dan Laut Sulawesi. Dari hasil penelitian, angin yang paling kuat adalah antara November hingga Februari, tetapi secara purata, Disember adalah kelajuan angin yang paling kuat yang direkodkan di kebanyakan lokasi. Laut China Selatan merupakan rantau yang paling kasar sepanjang tahun berbanding dengan laut yang lain. Disimpulkan bahawa menggunakan data altimetri, kita dapat menyelesaikan kelemahan pengukuran konvensional dalam hal pengagihan data spatial.

Kata kunci: Kelajuan Angin Lautan; Altimeter Satelit; Tempoh Monsun

■1.0 INTRODUCTION

Most oceanographic research and study need the compilation of long-term databases of accurate oceanic properties such as significant wave height and wind speed. Before this, wave climate data are gathered through the deployment of oceanographic buoys and more recently through the use of numerical models (Caires et al. 2004). Both techniques have their own disadvantages. For instance, in-situ measurement using buoy clearly have limitation in terms of data coverage (spatially) andvery expensive in term of deployment and maintenance.

Meanwhile, using model data actually can solve all these disadvantages but the biggest challenge for this technique relies critically on the accuracy of the model. Even though modern-day models contain sophisticated representations of wind–wave physics, the accuracy of such models are still limited (Tolman 2002). For instance, studies conducted byDobson et al (1987) and (Monaldo1988) have shown that active remote sensing satellites, particularly Ku-band radar altimeter systems, are capable of measuring significant wave height and wind speed to an accuracy comparable to in-situ observations (e.g., buoys).

2.0 ALTIMETER MEASUREMENT CONCEPT

The basic principle of satellite altimeter is based on the pulse that is reflected at the sea surface and backscattered according to wind and waves. The pulsethen will be received by the altimeter antenna after a few mili-seconds. There are three main parameters in reflecting the pulse from the ocean; they are the slope of the leading edge of the returned echo for wave height determination, travel time to measure distance to sea level and the energy of the impulse response for wind speed determination (Bosch, 2010). Meanwhile, the independent tracking systems are used to compute the satellite's three-dimensional position relative to a fixed Earth coordinate system (Din et al., 2012).

However, the situation is far more complex in practice. Several factors have to be taken into account for the corrections of altimeter range measurements such as orbit error (radial component) and instrumental effects such as electronic time delay, clock (oscillator) drift , offset antenna phase centre, centre of gravity, time lagging of observations, doppler shift error and so on. Another correction to be done is the atmospheric refraction due to ionosphere, troposphere (dry component) and troposphere (wet component). Other component that also can affect the signal is ocean surface such as ocean tides, earth tides; electromagnetic bias (sea state) and inverted barometer effect (Bosch, 2010). All of the effect and the correction can be refer to Figure 1.

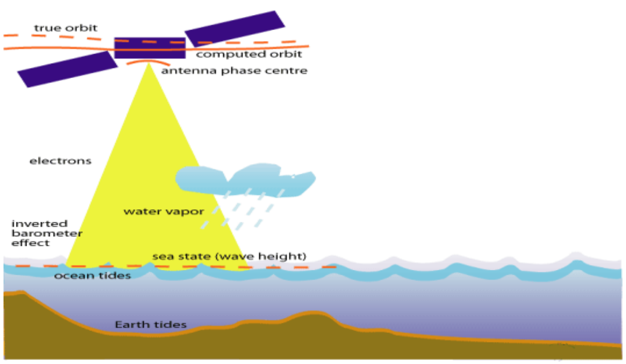


Figure 1 Corrections for altimeter range measurements (Bosch, 2010)

The schematic diagram of satellite radar altimeter system and its principle is depicted in Figure 1. By using a similar notation to Fu and Cazenave (2001), the corrected range $R_{corrected}$ is related to the observed range R_{obs}as :

$$R_{corrected} = R_{obs} - \Delta R_{dry} - \Delta R_{wet} - \Delta R_{iono} - \Delta R_{ssb}$$

Where,

$R_{obs} = c\, t/2$ is the computed range from the travel time t; observed by the on-board ultra-stable oscillator (USO), and c is the speed of the radar pulse neglecting refraction.

$\Delta Rdry$: Dry tropospheric correction
$\Delta Rwet$: Wet tropospheric correction
$\Delta Riono$: Ionospheric correction
$\Delta Rssb$: Sea-state bias correction

3.0 RADAR ALTIMETER DATABASE SYSTEM (RADS)

Nowadays, altimetry data has been dispensed through agencies like NOAA, AVISO, EUMETSAT and PODAAC. Aside that, the NOAA laboratory and the Delft Institute for Earth-Oriented Space Research (DEOS) for Satellite Altimetry has been collaborating in the development of Radar Altimeter Database System (RADS). The RADS is established in a harmonized, validated and cross-calibrated sea level database from all satellite altimeter missions. In RADS, users are able to access the most present range and geophysical corrections and also can produce their own altimetry products based on their particular interest (Andersen and Scharroo, 2011).

In the frame of RADS, the DEOS is developing a database that incorporates validated and verified altimetry data products. Besides, the database is also consistent in accuracy, correction, format and reference system parameters. The capability of such a database will attract users with less satellite altimeter expertise like advisory councils, water management authorities and even high schools (Naeije et al., 2000). This system also caters for the needs of scientists and operational users to have value-added sea level data readily at one's disposal (Lucy Mathers, 2005). Currently, RADS enables users to extract the data from several present and past satellite altimeter missions like Geosat, ERS-1, ERS-2, ENVISAT, TOPEX/Poseidon (T/P), JASON-1 and JASON-2. The current status and detail information of the altimetry data in the RADS is shown in Table 1.

Table 1 Status of RADS (Source: http://rads.tudelft.nl/rads/status.shtml)

Altimeter	Phase	Time	Cycles	Passes	Records
GEOSAT	A	31 Mar 1985 - 30 Sep 1986	001 - 025		
	B	08 Nov 1986 - 30 Dec 1989	026 - 093		
	D	31 Mar 1985 - 30 Sep 1986	001 - 025	61152	104395824
ERS-1	A	01 Aug 1991 - 14 Dec 1991	001 - 046		
	B	14 Dec 1991 - 25 Mar 1992	047 - 081		
	C	14 Apr 1992 - 20 Dec 1993	083 - 101		
	D	24 Dec 1993 - 10 Apr 1994	103 - 138		
	E	10 Apr 1994 - 28 Sep 1994	139 - 140		
	F	28 Sep 1994 - 21 Mar 1995	141 - 143		
	G	24 Mar 1995 - 02 Jun 1996	144 - 156	47890	83644555
TOPEX	A	25 Sep 1992 - 11 Aug 2002	001 - 364		
	B	20 Sep 2002 - 08 Oct 2005	369 - 481		
	N	11 Aug 2002 - 20 Sep 2002	365 - 368	111960	264208509
POSEIDON	A	01 Oct 1992 - 12 Jul 2002	001 - 361	7472	15718917
ERS-2	A	29 Apr 1995 - 04 Jul 2011	000 - 169	148130	168866998
GFO-1	A	07 Jan 2000 - 17 Sep 2008	037 - 223	82623	150249181
JASON-1	A	15 Jan 2002 - 26 Jan 2009	001 - 259		
	B	10 Feb 2009 - 03 Mar 2012	262 - 374		
	C	07 May 2012 - 05 Sep 2012	382 - 394	95120	259592804
ENVISAT1	B	14 May 2002 - 22 Oct 2010	006 - 094		
	C	26 Oct 2010 - 08 Apr 2012	095 - 113	98894	258081831
JASON-2	A	22 Jun 2008 - 05 Sep 2012	998 - 153	39271	125238769
Total				692512	1429997388

In Universiti Teknologi Malaysia (UTM), the RADS system has been installed since 2005 in the frame of the SEAMERGES project, an EU funded project (AUNP) that aimed for knowledge, methods and data exchange related to satellite altimetry, InSAR and GPS (www.deos.tudelft.nl/seamerges). Several universities and research group from France, Netherland, Malaysia, Indonesia and Thailand are participating in this geodetic education and geodetic research project. The main goal of the SEAMERGES project is to accomplish the knowledge transfer, expertise and technology from Europe to South East Asia.This is to locally enable the geodetic research at higher-level and to initiate the implementation of these technologies in the water management and risk assessment applications. It also aims at encouraging the scientific cooperation and collaboration among South East Asia countries.

■4.0 MATERIALS AND METHODS

This research utilises data from six satellite missions TOPEX, ERS-2, ERS-1, JASON-1, JASON-2 and ENVISAT from year 1993 until year 2011.These data were combined to produce wind speed characteristics. In order to densify our data points, monthly average of the data were griddedon a 0.25° x0.25° square block.

Furthermore, to study the seasonal variation effect, the wind speed from January 1993 until December 2011were averaged based on monsoon season period, Northeast Monsoon (November, December, January and February), Southwest Monsoon (May, June, July and August), first Inter-monsoon (March and April) and second Inter-monsoon (September and October).

■5.0 RESULTS

In a single year, the strongest wind speed varyusually between November to February, but on average,December is the strongest recorded wind speed at most locations, especially at the open sea such as the South China Sea.

The average ofwind speed in each of monsoon seasons and two inter-monsoonperiods are shown in figure 2 to figure 5. In this figures, the South China Sea is the roughest region throughout the year, while more sheltered regions, for example around Malacca Straits, Sulu Sea and Celebes Sea are relatively calm. The seasonality varies slightly from region to region. For example, the Northeast Monsoon tends to be rougher than the other monsoon season period, for the inter-monsoon it is usually calmer period for all over the sea.

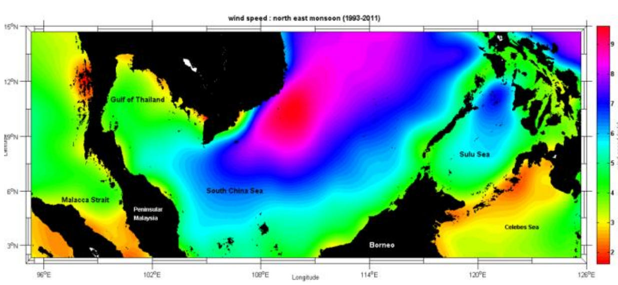


Figure 2 average of wind speed during Northeast Monsoon (1993-2011)

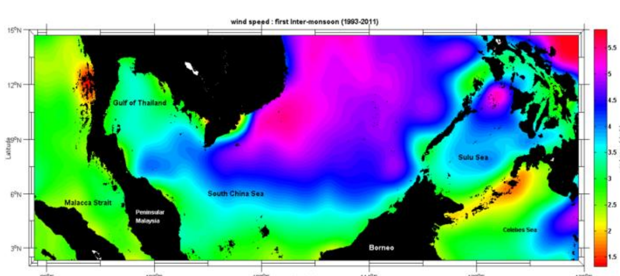


Figure 3 average of wind speed during first Inter- Monsoon (1993-2011)

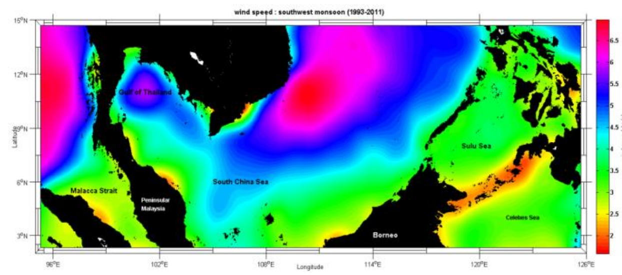


Figure 4 average of wind speed during Southwest Monsoon (1993-2011)

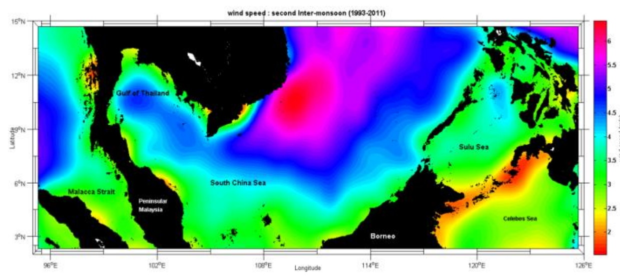


Figure 5 average of wind speed during second Inter- Monsoon (1993-2011)

■6.0 CONCLUSIONS

Remote sensing satellite technology is very useful and has a very huge potential in terms of measuring the dynamics of the earth either in ocean or on land. Satellite Altimeter or RADS technologyfall within this concept. It provides a series of continuous data for years and can cover up for almost every part of the sea. This means that this technology can be used as a complementary tool toaccount for the limitations of the conventional win speed measurements techniques. In conclusion, RADS and altimeter are extremely helpful in research, education and sea management.It is not only helpful for researchers but also for sea fearers, fisherman, and engineersas well as for local authorities especially, for coastal management.

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References

[1] Andersen, O., B., andScharroo, R. 2011. Range and Geophysical Corrections in Coastal Regions: And Implications for Mean Sea Surface Determination. *In Coastal Altimetry. Springer*.doi:10.1007/978-3-642-12796-0.

[2] Caires, S., A. Sterl, J. R. Bidlot, N. Graham, and V. Swail. 2004. Intercomparison of different wind–wave reanalyses. *J. Climate*. 17 : 1893–1913.

[3] C.P. Gommenginger, M.A. Srokosz, P.G. Challenor. 2003. An Empirical Model to Retrieving Ocean Wave Period. *Nadir Altimeter Data*.

[4] Din, A. H. M., Omar, K. M., Naeije, M., and Ses, S. 2012. Long-term Sea Level Change in the Malaysian Seas from Multi-mission Altimetry Data. *International Journal of Physical Sciences*. 7(10) : 1694–1712. 2 March, 2012. DOI: 10.5897/IJPS11.1596.

[5] Dobson, E., F. Monaldo, J. Goldhirsh, and J. Wilkerson. 1987. Validation of Geosat altimeter-derived wind speeds and significant wave heights using buoy data. *J. Geophys. Res*., 92(10) : 719–731.

[6] Fu, L., and Cazenave , A. (eds.). 2001. Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. *Academic Press*. San Diego, California. ISBN 0122695423.

[7] Lucy Mathers. 2005. Altimeter Database System. *Exploitation and Extension (RADSxx)*. 2005.

[8] Monaldo, F. 1988. Expected differences between buoy and radar altimeter estimates of wind speed and significant wave height and their implications on buoy-altimeter comparisons. *J. Geophys. Res*. 93 : 2285–2302.

[9] Naeije, M., Schrama, E., and Scharroo, R. 2000. The Radar Altimeter Database System project RADS. 487–490.

[10] Tolman, H. L. 2002. Validation of WAVEWATCH III version 1.15 for a global domain. *OMB Tech. Note*. 213 : 37.

[11] W. Bosch. 2010. Satellite Altimetry. *ESPACE*.

[12] S. Zieger, J. Vinoth, and I. R. Young. 2009. Joint Calibration of Multiplatform Altimeter Measurements of Wind Speed and Wave Height over the Past 20 Years. DOI: 10.1175/2009JTECHA1303.1. December